

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
14 December 2000 (14.12.2000)

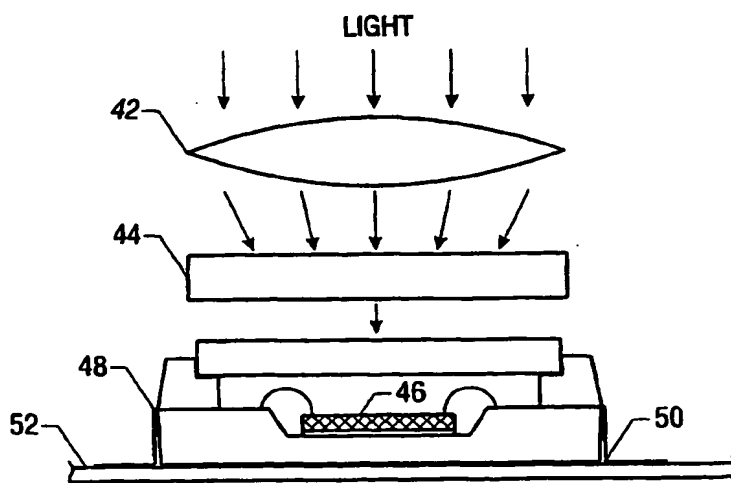
PCT

(10) International Publication Number  
**WO 00/76002 A1**

- (51) International Patent Classification<sup>7</sup>: H01L 31/0232, G02B 3/00, G03F 7/00, G02B 6/12
- (21) International Application Number: PCT/US00/13086
- (22) International Filing Date: 11 May 2000 (11.05.2000)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
09/324,880 3 June 1999 (03.06.1999) US
- (63) Related by continuation (CON) or continuation-in-part (CIP) to earlier application:  
US 09/324,880 (CON)  
Filed on 3 June 1999 (03.06.1999)
- (71) Applicant (for all designated States except US): INTEL CORPORATION [US/US]; 2200 Mission College Boulevard, Santa Clara, CA 95052 (US).
- (72) Inventors; and  
(75) Inventors/Applicants (for US only): ASSADI, Azar [CH/US]; 22575 Parkfield, Mission Viejo, CA 92692 (US). MOSSAHEBI, Parvin [US/US]; 4615 North 64th Street, Scottsdale, AZ 85251 (US). SENGUPTA, Kabul [IN/US]; 1170 W. Lisa Lane, Tempe, AZ 85284 (US).
- (74) Agent: TROP, Timothy, N.; Trop, Pruner, Hu & Miles, P.C., Suite 100, 8554 Katy Freeway, Houston, TX 77024 (US).
- (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU,

[Continued on next page]

(54) Title: MICROLENS FOR SURFACE MOUNT PRODUCTS



(57) Abstract: A photosensitive device (46) with a microlens array (44) may be packaged for surface mount packaging (48) and subsequent mass reflow processing without significantly degrading the optical performance of the microlens. The microlens may be formed using a series of heat steps of increasing time and temperature. In addition, the microlens may be bleached to prevent degradation of its optical transmissivity at temperatures normally associated with surface mount techniques.

WO 00/76002 A1

BEST AVAILABLE COPY



MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**Published:**

— *With international search report.*

- 1 -

Micro lens For Surface Mount ProductsBackground

This invention relates generally to photosensitive devices and in particular to the use of microlens arrays to increase the fill factor of such photosensitive devices.

Currently, surface mount packaging is enjoying considerable commercial acceptance in large part due to the fact that high volume connections may be made to circuit boards in a low cost fashion. In one such surface mount integrated circuit packaging technique, known as Quad Flat Package (QFP), the package may be connected to a circuit board, such as a printed circuit board (PCB), simply by positioning the package on the board and applying heat. The heat melts a plurality of contacts on one surface of the package, connecting the package to the board. This technique enables integrated circuits to be connected to circuit boards in an automated fashion at high speed and low cost.

Integrated circuit image sensors are also gaining increasing acceptance. Complementary metal oxide semiconductor (CMOS) imaging devices may be formed using conventional logic semiconductor fabrication processes. These devices can be made at high speed and at relatively low cost, producing devices with advanced electronic functions, in addition to the imaging functions.

A variety of photosensitive devices increase their fill factors with microlens arrays. The fill factor is a measure of the amount of incident light which actually makes its way onto the image sensing array. The microlens operates as a miniature lens, focusing light on each pixel making up the image sensing array.

Microlenses may be made of positive photoresist or sol gel. These microlens arrays may be formed directly on top of the image sensor, for example, by positioning the microlens array on top of a color filter array (CFA) which is situated over the image sensing array. Alternatively, the microlenses may be spaced over the image sensing array. In any case, the microlenses are generally heat sensitive and therefore have not been used, so far as the present inventors are aware, with surface mount packaging. It is believed that conventional surface mount packaging, which involves temperatures on the order of 225°C for a matter of minutes adversely affects conventional microlens arrays.

- 2 -

Therefore, there is a continuing need for techniques for enabling low cost packaging techniques to be applied to photosensitive devices with acceptable fill factors achieved using microlens arrays.

## 5 Summary

In accordance with one aspect, a method for forming a microlens includes forming a photosensitive device. A microlens is arranged over the device and the device is packaged. The packaged device is then exposed to a surface mount mass reflow.

## 10 Description of the Drawings

Figure 1 is a perspective view of one embodiment of a microlens array in accordance with one embodiment of the present invention;

Figure 2 is a flow diagram showing the steps used in one embodiment of the present invention to form microlenses using mass reflow techniques;

15 Figure 3 is a cross-sectional view of the array shown in Figure 2 after a heat-processing step;

Figure 4 is a cross-sectional view of a microlens array in the process of being fabricated; and

Figure 5 shows a device in use in accordance with one embodiment of the invention.

20

## Detailed Description

Referring to Fig. 1, a microlens array 10 may include a plurality of microlenses 12 separated by channels 14 in accordance with one embodiment of the present invention. With the illustrated microlenses 12, the rectangular or square shape decreases the amount of space  
25 wasted by the channels 14 and thereby improves the fill factor. The precise dome shape of the microlenses 12 may be adjusted by increasing or decreasing the curvature compared to that shown. In addition to rectangular microlenses, other conventional shapes may be used as well including circular, hemispherical microlenses.

The microlens array 10 can be formed of a substantially light transmissive, positive  
30 photoresist, such as novalac. The array 10 may withstand the mass reflow temperature steps involved in coupling surface mount packages to circuit boards. With conventional microlenses, the optical characteristics of the microlens would be degraded when exposed the

- 3 -

high surface mount temperatures that adversely affect the transmissivity of the lens and its shape. An improved photosensitive device using the microlens array 10 may make use of popular, low cost surface mount packaging processes.

Referring to Fig. 2, initially the material utilized to form the microlens is spin coated  
5 on an appropriate surface such as a CFA layer, a glass substrate or in some cases directly on a photosensitive device, as indicated at 26. While Fig. 2 illustrates the use of spin coating to deposit the material forming the microlenses, other known techniques may be utilized as well. Next, the coated material is subjected to a soft bake step, illustrated at 28. In one  
10 embodiment of the present invention, the microlens forming material may be coated to a thickness of about 3 microns and may be subjected to a soft bake step using a temperature of about 100°C, for example 110°C for 540 milliseconds. The amount of time and temperature utilized for the soft bake step may be variable and may be a function of the thickness of the coated material. Thereafter the baked coating is subjected to photolithography, as indicated at 30 in Fig. 2.

15 Following photolithography, the blocks 16 (which will become microlenses) may take the shape shown in Fig. 3 in one embodiment of the invention. In such case, the blocks are separated from one another by a trough 18 which may have a width of about 3.5 microns. Walls may be formed with a slope of about 3. In the embodiment illustrated, each of the blocks 16 has a length of about 9 microns. The blocks are patterned using conventional  
20 techniques such as photoresist processing techniques, as indicated at block 32.

The microlens blocks 16 are then bleached as indicated in block 34. The bleaching process is useful in preventing degradation of the microlenses when exposed to higher temperatures and to improving transmissivity.

The bleaching may be a quick bleach step on the order of 5 to 10 seconds, and in one  
25 embodiment the duration is from 6 to 7 seconds. The bleaching is done using deep ultraviolet (DUV) wavelength radiation that produces wavelengths of 350 to 430 nm., for example. A UV filter passes wavelengths above about 400 nm. This permits the bleaching time to be reduced compared to conventional bleaching, using broadband radiation, which may take on the order of thirty seconds. The DUV bleaching using wavelengths greater than 400 nm. is  
30 very effective in removing photoactive material from the photoresist material. The photoactive material is believed to be responsible for yellowing, transmissivity loss, and heat instability.

- 4 -

The bleached blocks 16 are then subjected to a reflow step 36. In one embodiment of the invention, the reflow step may involve temperatures of about 150°C, for example 160°C for about 120 seconds. As a result, the blocks shown in Fig. 3 melt to form the shape shown in Fig. 4. The microlenses 12 are separated by channels 14. The height T of the microlenses 12, in one embodiment of the present invention, may be about 2.8 microns and the lenses 12 may have a length of about 11.5 microns.

The lenses may now be exposed to a hard bake step (block 38) at a temperature of about 200°C, for example 225°C for about 2-3 minutes. Conventional processing generally optimizes the spacing between the individual microlenses, particularly to avoid overlapping. By optimizing instead for heat stability, a heat stable microlens may be produced.

Afterwards the imager with the microlenses 12 is packaged (block 40). Thereafter, the microlenses may be exposed to conventional temperatures utilized for mass reflowing surface mount packages without adversely affecting the optical characteristics of the lenses. In some embodiments, the microlenses are adapted to withstand temperatures of at least 225°C for at least one minute and in some cases at least two minutes. Not only is the transmissivity substantially unchanged in some embodiments, but the shape of the lens may be substantially unaffected as well.

Referring now to Fig. 5, a completed microlens array 44 may be positioned atop a photosensitive device 46 contained in a surface mount package 48. An external refractive lens 42 may focus light through the microlens array 44 onto the photosensitive device 46. In one embodiment of the invention, a windowed quad flat package 48 may be secured to a circuit board 52 using the leads 50 in accordance with conventional surface mount packaging techniques. Upon the application of heat, the leads 50 bond the package 48 to the circuit board 52. This may be done without adversely affecting the optical performance of the microlens array 44.

While the present invention has been described with respect to a limited number of embodiments, those skilled in the art will appreciate numerous modifications and variations therefrom. It is intended that the appended claims cover all such modifications and variations as fall within the true spirit and scope of the present invention.

What is claimed is:

- 5 -

- 1           1.     A method of forming a microlens comprising:  
2                 forming a photosensitive device;  
3                 arranging a microlens over said device;  
4                 packaging said device; and  
5                 exposing said packaged device to a surface mount mass reflow step.
  
- 1           2.     The method of claim 1 further including bleaching said microlens forming  
2     material using deep ultraviolet radiation.
  
- 1           3.     The method of claim 2 including filtering out wavelengths less than about 400  
2     nanometers.
  
- 1           4.     The method of claim 3 including bleaching for about 10 seconds.
  
- 1           5.     The method of claim 1 further including exposing said microlens forming  
2     material to a series of processing steps of increasing temperature.
  
- 1           6.     The method of claim 5 including exposing said microlens forming material to  
2     three heat steps each having progressively higher temperatures for longer periods of time.
  
- 1           7.     The method of claim 1 including using positive photoresist as the microlens  
2     forming material.
  
- 1           8.     The method of claim 1 including patterning a microlens forming material in a  
2     first shape and exposing said material to heat to cause said material to change shape.
  
- 1           9.     The method of claim 8 further including exposing said material to a first  
2     thermal treatment of approximately 100°C, exposing said material to a second thermal  
3     treatment of approximately 150°C and exposing said material to a third thermal treatment of  
4     approximately 200°C.

- 6 -

1           10.    The method of claim 1 including hard baking a microlens forming material at  
2 a temperature of at least 200°C for at least about two minutes.

1           11.    The method of claim 1 including hard baking a microlens material at a  
2 temperature and for a time sufficient to enable said material to be heat stable at temperatures  
3 of over 200°C for at least two minutes.

1           12.    A packaged photosensitive device comprising:  
2                   a photosensitive array;  
3                   a microlens formed over said photosensitive array; and  
4                   a package containing said photosensitive array, said package adapted to be  
5 secured to a circuit board using surface mount techniques.

1           13.    The device of claim 12 wherein said microlens is rectangular.

1           14.    The device of claim 12 wherein said microlens is formed of positive  
2 photoresist.

1           15.    The device of claim 12 wherein said microlens is deep ultraviolet bleached.

1           16.    The device of claim 12 wherein said microlens is adapted to withstand a  
2 temperature of at least 200°C for two minutes.

1           17.    The device of claim 12 wherein said package is a windowed quad flat package.

1           18.    A method of forming a heat stable microlens comprising:  
2                   bleaching a microlens forming material using deep ultraviolet radiation having  
3 a wavelength above about 400 nanometers; and  
4                   hard baking said material at a temperature and time sufficient to enable said  
5 material to be heat stable at temperatures on the order of 200°C for least two minutes.

- 7 -

1           19.    The method of claim 18 including hard baking said material for at least two  
2 minutes at a temperature of at least 200°C.

1           20.    The method of claim 18 including bleaching said material for about 10  
2 seconds.

1/3

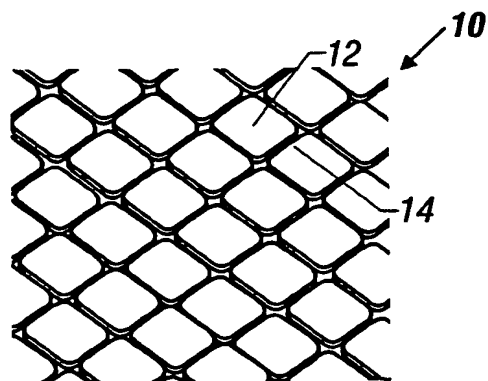


FIG. 1

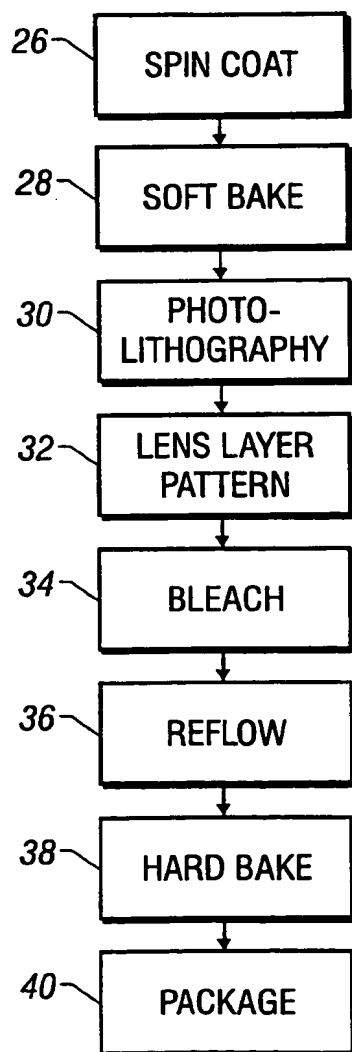


FIG. 2

2/3

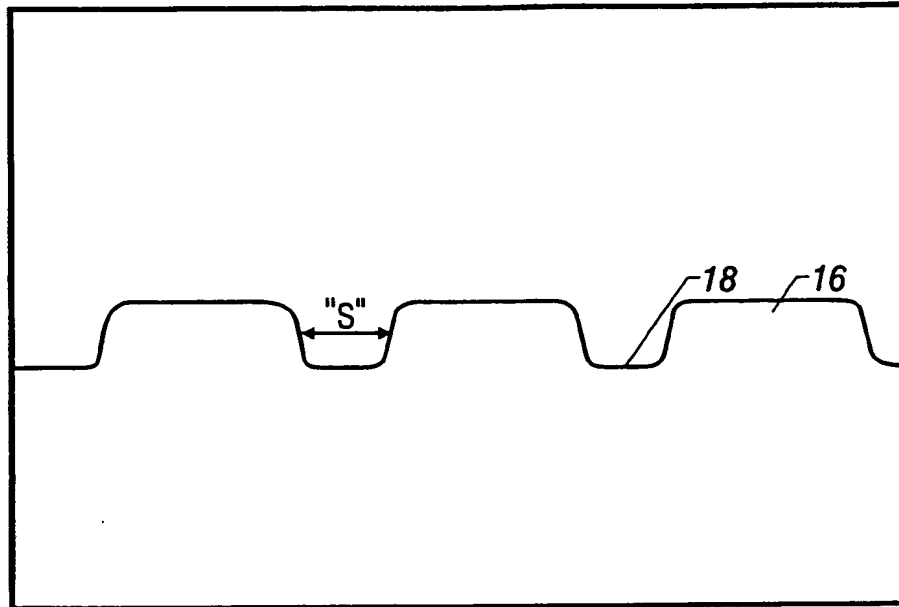


FIG. 3

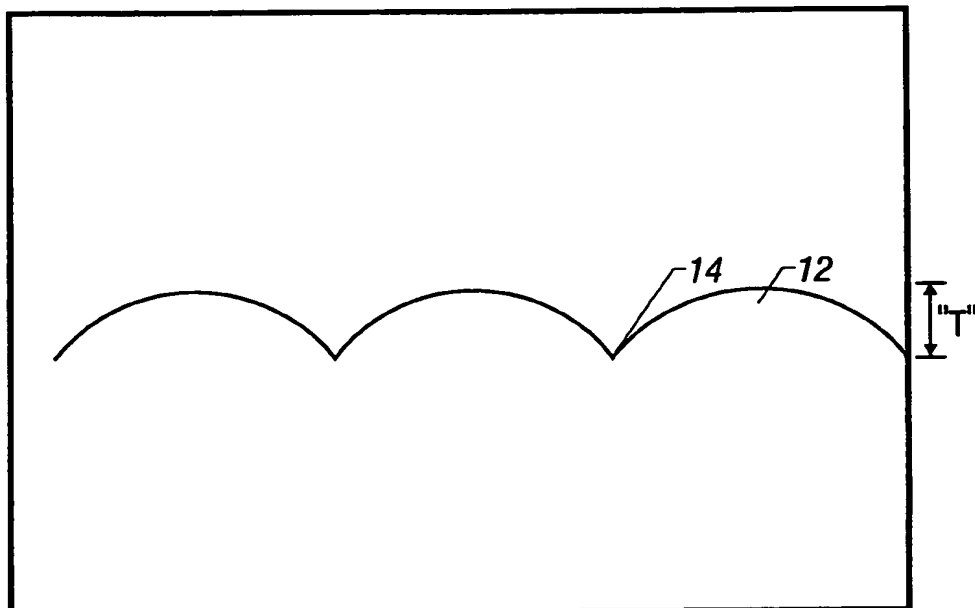
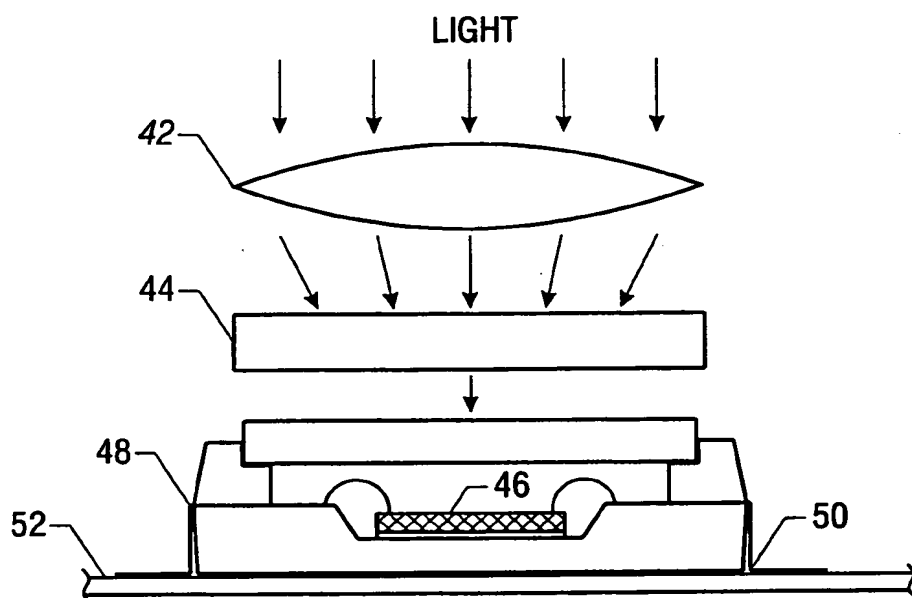


FIG. 4

3/3

**FIG. 5**

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/JS 00/13086

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H01L31/0232 G02B3/00 G03F7/00 G02B6/12

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H01L G02B G03F B29D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC, IBM-TDB

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 526 776 A (IBM)	1,12
Y	10 February 1993 (1993-02-10)	
	column 3, line 2 - line 50	2-4,7,8, 10,14,15
A	column 4, line 46 -column 6, line 19 column 10, line 4 -column 11, line 10 column 11, line 35 - line 51 abstract; figures 1,7A,7B,10	13
X	KATO T ET AL: "21 GBIT/S/CM2 THROUGHPUT DENSITY TWO-DIMENSIONAL ARRAY OPTICAL INTERCONNECTION CONSTRUCTION" ELECTRONICS LETTERS,GB,IEE STEVENAGE, vol. 29, no. 19, 17 September 1993 (1993-09-17), pages 1722-1723, XP000397021 ISSN: 0013-5194	1,12
A	abstract; figure 1	13
	— -/-	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

2 August 2000

Date of mailing of the international search report

09/08/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3018

Authorized officer

Narganes-Quijano, F

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/13086

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 33091 A (BORRELLI NICHOLAS F ;CORNING INC (US); MOORE CHAD B (US)) 30 July 1998 (1998-07-30)	18,19
Y	page 7, line 19 - line 26	2-4,7, 10,14,15
A	page 10, line 1 - line 16	5,6,9, 11,16,20
	abstract	
Y	US 4 694 185 A (WEISS ARMIN K) 15 September 1987 (1987-09-15)	7,8,14
A	column 1, line 24 - line 32	1-6, 10-13, 15-20
	abstract; figures 1-7; examples 1-13	
A	US 5 458 716 A (ALFARO RAFAEL C ET AL) 17 October 1995 (1995-10-17)	1,12,17
	column 3, line 37 -column 5, line 9 column 7, line 22 - line 30 abstract; figures 1-3	
A	EP 0 368 800 A (CIBA GEIGY AG) 16 May 1990 (1990-05-16)	5-7, 9-11,14, 16,18,19
	page 2, line 27 - line 49	
A	DE 38 35 737 A (CIBA GEIGY AG) 26 April 1990 (1990-04-26)	2-4,7, 11, 14-16, 18-20
	page 2, line 40 - line 47	
P,A	WO 99 50914 A (INTEL CORP ;LI ZONG FU (US)) 7 October 1999 (1999-10-07)	1-20
	page 4, line 2 -page 8, line 36 abstract; figures 1-6	
P,A	WO 99 50052 A (WESTER NEIL ;INTEL CORP (US)) 7 October 1999 (1999-10-07)	1-20
	page 6, line 9 - line 23 abstract; figure 2	

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/JS 00/13086

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0526776	A	10-02-1993	US 5200631 A JP 5211283 A	06-04-1993 20-08-1993
WO 9833091	A	30-07-1998	EP 1008012 A WO 9833222 A	14-06-2000 30-07-1998
US 4694185	A	15-09-1987	CA 1271829 A EP 0242663 A JP 62254474 A	17-07-1990 28-10-1987 06-11-1987
US 5458716	A	17-10-1995	US 5650915 A	22-07-1997
EP 0368800	A	16-05-1990	DE 3837612 A CA 2002149 A JP 2181149 A US 5104768 A	23-05-1990 05-05-1990 13-07-1990 14-04-1992
DE 3835737	A	26-04-1990	CA 2000924 A EP 0364949 A JP 2163740 A US 5106718 A	20-04-1990 25-04-1990 25-06-1990 21-04-1992
WO 9950914	A	07-10-1999	AU 3083999 A	18-10-1999
WO 9950052	A	07-10-1999	US 6083429 A AU 3098999 A	04-07-2000 18-10-1999

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**